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New 40Ar/39Ar ages of impact glass ejecta from the Lonar crater: comparison with previous melt rock results and implication for planetary impacts.

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Asteroid impacts play an important role in the evolution of planetary surfaces. In the inner solar system, the large majority of impacts occur on bodies (e.g., asteroids, the Moon, Mars) covered by primitive igneous rocks. The Lonar crater is a 1.88-km diameter; Quaternary age crater located on the ∼66 Ma old Deccan basaltic traps, in Maharashtra (India) [1] and is one of the very few craters on Earth emplaced directly on basaltic lava flows, acting as a natural laboratory for studying planetary impact events [2].

Our previous study [3] included twelve 40Ar/39Ar step-heating analyses on four melt rock samples. These results yielded an unambiguous age of 570 ± 47 ka. They also showed that the 40Ar/36Ar ratios of the samples were indistinguishable from the atmospheric composition, demonstrating a near-complete degassing of low viscosity melt such as basalts during even small impact. Impact glass ejecta are interesting to compare to melt rocks as they generally have a much smaller surface ratio than the melt sheet, implying that they should quench rapidly and perhaps be able to retain part of their inherited 40Ar. On the other hand, due to their relative small size compared to melt sheet, glass ejecta have a smaller diffusive distance to overcome and might be in fact easier to degas [4].

In this study, we obtained three inverse isochron ages of 429 ± 205 ka (P=0.12), 627 ± 201 ka (P=0.33) and 890 ± 387 ka (P=0.55) on three impact ejecta collected around the Lonar crater. The weighted mean age of the impact ejecta is 573 ± 130 ka (P=0.08) and is indistinguishable from the mean age of ∼570 ka obtained for the melt rock, thereby confirming the age previously proposed by [3]. The ejecta glasses have distinct trapped 40Ar/36Ar ratios ranging from 290 ± 14 to 306 ± 5 (relative to an adopted value of 299). The calculated fraction of inherited 40Ar* [4] range from 0 to 1.2% demonstrating that impact ejecta are generally well degassed of their inherited 40Ar*. However, these values seem, in average, higher than for impact melt rocks (0% inherited Ar) and thus seem to suggest that the quenching component plays a major role in the ability of an ejecta to completely loose its 40Ar*. The presence of inherited isotope parents in impact ejecta has consequences for the study of isotopic ages of extraterrestrial impact ejecta (e.g. lunar spherules [5]) and implies that multiple analyses of each sample (e.g. 40Ar/39Ar step heating, U/Pb spots) and isochron calculations are indispensable to calculate accurate impact ages.

[1] Fredriksson et al., Science 1973; [2] Osae et al., MAPS 2005; [3] Jourdan et al., Geology 2011; [4] Jourdan et al., GCA 2007; [5] Culler et al., Science 2000.